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PROCESS AND APPARATUS FOR SLIP CASTING UNDER THE ACTION OF PRESSURE
[Verfahren und Vorrichtung zum Schlickergiessen unter Druckeinwirkung]

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Specification

[0001]

The invention relates to a process for slip casting under the action of pressure for producing ceramic material, especially hollow ceramic goods, as well as to an apparatus for slip casting under the action of pressure for the production of previously cited objects.

[0002]

Shaping apparatuses are already known for use in the slip casting of ceramic objects using pressure, and pressure slip casting installations are also known. In such pressure slip casting, slip is introduced into a hollow space of a mold and is placed under pressure, for which appropriate slip lines and pressure medium lines are provided that empty into the hollow space of a mold, which space is surrounded by one or several form parts. Contaminations in the ceramic goods to be produced and also in the walls of the mold part or parts limiting the hollow mold space due to unavoidable leaky spots in the hydraulic system can occur as a function of the selected pressure medium, for example, pressure oil, for the traditional producing of pressure with piston pumps, which comprise, for example, two pistons connected to one another via a piston rod, of which one is loaded with pressure oil and the other applies the appropriate pressure on the slip. In the case of the mold parts, a time-consuming and expensive cleaning is then necessary, during which the pressure-slip casting installation must stand still so that a reduced production rate must be accepted. Upon a contamination of the ceramic it must be separated out as a rejected item, which adversely effects the work efficiency of such an installation.

[0003]

If a slip pump is used to transport the slip into the hollow mold space and if a piston is used for producing the pressure in the previously known procedures, it is necessary in such a pressure-slip casting installation before operating pauses to let the slip out of the lines and to clean the latter. Therefore, standing times had to be previously avoided as much as possible during pressure-slip casting. Also, the pressure-slip casting was mainly used for commodity ceramics, for example, for sanitary requirements and the like.

[0004]

The invention has the problem of making available a process and an apparatus for slip casting under the action of pressure for the production of ceramic goods, in particular hollow ceramic goods, with which the described difficulties can be overcome and even high-grade ceramic goods, especially hollow ceramic goods such as pots and the like, can be effectively produced in an economical and simplified manner.

[0005]

According to the invention a process is made available to this end for slip casting under the action of pressure for producing ceramic goods, especially hollow ceramic goods, in which slip is filled into a hollow space of a mold formed by a mold and placed under pressure for forming bodies for the ceramic goods. This process is distinguished according to the invention in that after the filling of the hollow mold space with slip, an inflatable hollow body element of non-porous but flexible material is introduced into the slip by immersion into the slip that is then inflated by fluid pressure in the inner

space of the hollow body element in the manner of a balloon for loading the slip with pressure when the mold is closed.

[0006]

Thus, in the process according to the invention, at first the filling of the hollow mold space limited by the mold with slip takes place, for which, for example, slip lines with valves in them and with a customary slip pump are used that can remain filled with slip even during standstill times since the pressure loading of the slip filled into the hollow mold space takes place in the process of the invention separately from the slip filling with the aid of the hollow body element that can be inflated like a balloon, for which a fluid pressure medium is introduced into the inner space of the hollow body element with the mold closed. Instead of a slip pump, a slip supply system that operates without pressure can also be used in which the slip is transported into the hollow mold space supported only by gravity. In the invention the fluid pressure medium does not come in direct contact with the slip mass since the hollow body element is produced from a non-porous material and therefore only the outer skin of the hollow body element, which can be inflated like a balloon, comes in direct contact with the slip mass. Thus, adverse effects due to possible contaminations of the slip mass caused by the pressure medium and also in the area of the walls of the mold for the mold parts limiting the hollow mold space can be effectively avoided, so that on the one hand, in particular, even high-grade hollow ceramic goods can be produced effectively and with a high production rate, and on the other hand the procedure method is, in particular, extremely maintenance-friendly since no time-consuming and cost-intensive cleaning operations or post-treatment operations on the walls of the hollow space of the mold are necessary and/or no rejects need to be feared for the ceramic good. In particular, even the slip supply apparatuses

do not need to be emptied and cleaned, for example, during standstill times. This considerably reduces the maintenance costs.

[0007]

Furthermore, the process in accordance with the invention allows an inflatable hollow body element to be adapted as regards its form and/or shape to the particular ceramic good to be produced even as regards it size. This is especially very advantageous in the production of hollow ceramic goods such as pots or the like. Furthermore, in the case of wear, the hollow body element can be rapidly and readily exchanged and replaced.

[0008]

The fluid pressure in the inner space of the hollow body element is preferably produced by water and can be on the order of approximately 20 to approximately 40 bar. Since no fluid pressure medium that tends to become contaminated is used, all problems possibly associated therewith can be eliminated. Also, the pressure loading can be regulated and controlled here in a constructively simple manner and in a desired manner.

[0009]

The hollow body element is preferably introduced in the process of the invention in the non-inflated state into the slip to the desired position and then the fluid pressure is built up in the inner space of the hollow body element preferably in a gradually rising manner. During the immersion of the non-inflated hollow body element, slip is displaced in the hollow mold space, preferably in such a manner that the excess slip essentially rises over the actual hollow mold space determining the ceramic good and that,

however, it is also ensured that the entire hollow mold space formed by the mold is completely and uniformly filled with slip. The fluid pressure loading can be controlled in time in the process in accordance with the invention and is maintained until at least one partially solidified ceramic body has been formed in the hollow mold space.

[0010]

When this ceramic body has been formed and has solidified to the extent that it is capable of transport as such, the fluid pressure in the inner space of the hollow body element is reduced, preferably gradually becoming smaller. Even this reduction can optionally be controlled in time in a suitable manner. A coordination with the particular ceramic good to be produced is also possible with all these control measures without problems, for example, using simple tests.

[0011]

Finally, the hollow body element is then removed after the body formation without fluid pressure from the hollow mold space. The ceramic good produced in this manner in accordance with the invention can then be removed in a suitable manner from the hollow mold space and, in the case of a multipartite mold, the individual mold parts can then be separated from each other so that the ceramic good formed in this manner is accessible for all further treatments and can optionally be transported to further treatment installations.

[0012]

In the process in accordance with the invention, the inflatable hollow body element is preferably connected in a movable manner to a mold closure part. This can bring it about in a simple manner as

regards the engineering that the hollow mold space, which was previously open and filled with slip, is tightly closed upon introduction of the inflatable hollow body element, and that when the ceramic good has been formed as regards the shaping of its form in the hollow mold space, the mold can be partially opened at the same time as the removal of the inflatable hollow body element. This allows several movement operating sequences to be combined during the carrying out of the process in accordance with the invention in order to obtain an improved effectiveness of production.

[0013]

According to a further aspect of the invention, an apparatus for slip casting under the action of pressure for producing ceramic goods, especially hollow ceramic goods, with a mold surrounding a hollow mold space for slip casting under the action of pressure is made available that is distinguished in that a hollow body element of non-porous but flexible material is provided that can be inflated like a balloon by fluid pressure in the inner space and that can be immersed into slip filled into the hollow mold space and removed from it in the emptied state after the body formation. In the state of inflation like a balloon, the hollow body element produces a pressure loading on the slip in the hollow mold space, during which, however, the pressure-loading medium comes neither in direct contact with the slip nor with the delimiting walls of the hollow mold space. As a result, the apparatus of the invention is designed in a constructively uncomplicated manner and allows reliable operation.

[0014]

The inflatable hollow body element is preferably fastened on a free end of a rigid tube section as holder that introduces the fluid pressure medium into the inner space of the hollow body. This tube

section serving as holder thus also serves at the same time to introduce fluid pressure medium and reliably holds the inflatable hollow body element of non-porous but flexible material fast on its free end.

[0015]

The inflatable hollow body element is preferably connected via the tube section to a mold closure part and can be moved together with the latter for immersion and removal. Thus, the mold limiting the hollow mold space can be completely closed or again at least partially opened at the same time as the in and out traveling movement of the inflatable hollow body element.

[0016]

A separate slip line for filling the still partially open hollow space of the mold with slip is preferably provided without coming in contact with the inflatable hollow body element so that the slip supply in the apparatus of the invention also takes place bodilly separated from the pressure loading by the inflatable hollow body element. Thus, no emptying and/or cleaning of the conduits guiding the slip such as pumps, valves and the like is necessary. This ensures a maintenance-friendly operation of the apparatus of the invention.

[0017]

In summary, it is essential in the process in accordance with the invention and the apparatus in accordance with the invention that the slip in the hollow mold space not be directly loaded by a pressure medium but rather that the pressure loading take place separately by an inflatable hollow body element after the filling of the hollow mold space with slip. This allows on the one hand contaminations on the mold and on the ceramic material to be avoided and in particular hollow ceramic objects to be produced

with a high quality in a universal and effective manner since the size, form and shape of the inflatable hollow body element can be adapted to the particular existing requirements to be taken into account during the production of the desired ceramic good, in particular the desired hollow ceramic good. A removal of excess slip is readily possible by an appropriate turning of the mold after the body formation is complete and at a reduced pressure in the inflatable hollow body element. Furthermore, the pressure loading can be regulated in a sensitive manner by the inflatable hollow body element.

[0018]

The invention is explained in detail in the following using a preferred embodiment without any limitation with reference made to the attached illustration.

[0019]

Figure 1 shows an apparatus for slip casting under the action of pressure in a partially open mold in order to illustrate the filling of the hollow mold space with slip.

[0020]

Figure 2 shows a view similar to that of Figure 1 after the filling of the hollow mold space with slip and with a partially emerged, inflatable hollow body element in conjunction with a mold closure part; and

[0021]

Figure 3 shows a view similar to that of Figure 2 in which the inflatable hollow body element for the pressure loading of the slip in the hollow mold space is shown in an at least partially inflated state.

[0022]

In the figures of the illustration the same or similar parts are provided with the same reference numerals. In the following the production of a pot as an example of a hollow ceramic good by means of slip casting under the action of pressure in accordance with the invention is explained by way of example. Of course, the invention is not limited to this exemplary application but rather differently designed ceramic goods as well as hollow ceramic goods with very varied shapes can also be produced in accordance with the invention. Thus, for example, sanitary articles such as wash basins, toilet bowls and the like can also be considered.

[0023]

Figure 1 shows a mold designated in its entirety by 1 that is designed, for example, in a multipartite manner and can comprise individual mold parts of the same and/or different materials. An opening 3 is provided in an upper mold part 2. Mold 1 encloses a hollow mold space designated in its totality by 4 that is contoured and designed in accordance with the ceramic good to be produced. Slip 7 is filled via opening 3 into the hollow mold space through a schematically represented slip supply apparatus 5 that can comprise a slip line 6, optionally with valves and a pump. The filling of hollow mold space 4 with slip 7 can also optionally take place without pressure solely under the utilization of gravity. In the view in Figure 1, the hollow mold space 4 is filled at least partially with slip 7, as is illustrated with a horizontal shading.

[0024]

After the filling of hollow mold space 4 with slip 7, a hollow body element 8 that is fastened on a tube section 9 as holder is then introduced, as is illustrated in detail in Figure 2, in the non-inflated state advantageously together with a mold closure part 10 into slip 7 in hollow mold space 4. Hollow body element 8 is produced from a non-porous but flexible material and it can be inflated by a suitable internal pressure in the manner of a balloon. During the introduction of hollow body element 8, slip 7 is displaced in hollow mold space 4, which brings it about that hollow mold space 4 is filled up approximately completely with slip 7 independently of the complicatedness of it shape. As Figure 2 illustrates, slip 7 rises slightly in opening 3 during the immersion of hollow body element 8 and by its displacement. Mold 1 and also hollow mold space 4 filled with slip 7 are then tightly sealed with the aid of mold closure part 10.

[0025]

It now becomes clear, referring to Figure 3, that the inner space of hollow body element 8 is loaded with a fluid pressure that can be approximately 20 to approximately 40 bar, preferably via tube section 9. All traditional pressure media can be considered as a pressure medium, and in particular even the use of water as a pressure medium is extremely advantageous in the process according to the invention. As a result of the internal pressure in hollow body element 8, it is inflated like a balloon and the slip surrounding the outer wall of hollow body element 8 is loaded with pressure in a suitable manner. This pressure preferably acts on all sides via the outside of hollow body element 8 on the surrounding slip. This also achieves a pressure loading that is as uniform as possible. Hollow body element 8 is preferably loaded by the suitable fluid medium in a gradually rising manner with a corresponding internal pressure

so that slip 7 is displaced more and more until finally the final shape of the inner hollow space of the ceramic material to be produced has been achieved.

[0026]

Inflatable hollow body element 8 can be adapted in a non-complicated manner to the particular desired requirements regarding shape, size and material. During the production of a pot, as in the example shown in the illustration, hollow body element 8 is inflated like a balloon similar to the form of a light bulb in order to form the inner hollow space of the pot in a correspondingly contoured manner.

[0027]

The apparatus is then maintained, for example, in the state shown in Figure 3 until a ceramic body has been formed by solidification in hollow mold space 4. Such a ceramic body is solidified at least in as far is it can be independently handled largely without damage after having been removed from mold 1 and, for example, can be further transported to appropriate further processing apparatuses such as a drying apparatus, a burning apparatus and the like.

[0028]

After this body formation, for which different time periods are required as a function of the slip 7 used and of other requirements, the inflatable hollow body element 8 is emptied, i.e., the internal fluid pressure in hollow body element 8 is reduced, also preferably in a gradually decreasing manner. As soon as hollow body element 8 is in the state without fluid pressure, it is then preferably moved out of hollow mold space 4 along with mold closure part 10, namely, advantageously in such a manner that mold closure part 10 is also raised off at least partially to a slight extent or also completely. The apparatus

then assumes, for example, the state shown in Figure 1, aside from the fact that now a solidified ceramic body has now been formed in hollow mold space 4 and surrounds a hollow inner space in the example shown so that it is, for example, a hollow ceramic object. Then, the excess slip still in hollow mold space 4 can be, for example, poured off via opening 3 by appropriately turning mold 1 or removed in some other suitable manner, for example, supported by gravity. When the excess slip 7 has been removed out of hollow mold space 4 of the formed ceramic body and has been conducted away, mold 1 can then be opened further and completely in that the appropriately associated mold parts of mold 1 are moved apart from one another so that the ceramic body is, for example, almost totally released and, for example, remains standing upright only on its bottom on an associated mold part of the mold. The ceramic body formed in this manner can now be taken out of mold 1 and transported to the appropriately suitable posttreatment apparatuses.

[0029]

In the process in accordance with the invention, the pressure medium for pressure loading of hollow body element 8 makes contact neither with the slip nor with the ends limiting hollow mold body 4. Hollow body element 8 is produced, namely, from a non-porous material so that the pressure loading medium cannot escape via the wall of hollow body element 8 and diffuse, for example, into the slip. Therefore, contaminations of the mold parts of mold 1 and/or of slip 7 and/or of the ceramic body formed using them can be effectively excluded in an effective manner. Therefore, expensive cleaning work on mold 1 and the cause for rejection goods can be eliminated.

[0030]

The size, shape and material of hollow body element 8 that can be inflated like a balloon can be adapted without problems to the particular requirements, as a result of which the form and the type of the ceramic good to be produced are also considerably influenced. In particular, the filling of mold 1 with slip 7 is also brought about completely separately from the shaping of the ceramic body in hollow mold part 4 using inflatable hollow body element 8, so that the slip supply system can be selected as regards its design independently from the shaping of the ceramic body in hollow mold space 4. Also, the fluid pressure medium for inflating hollow body element 8 can be selected without taking into consideration the design of slip supply apparatus 5. This achieves a largely universal usability of the process of the invention and of the apparatus of the invention during the production of ceramic goods by slip casting under the action of pressure. In particular, the pressure loading medium for inflatable hollow body element 8 can be selected in the particular suitable manner.

[0031]

Of course, the number and the design of the mold parts of mold 1 can be changed in accordance with the ceramic good to be produced.

[0032]

Different materials can be considered for the production of the inflatable hollow body element that all have the fact in common that they have a non-porous but flexible behavior at least in the ready-to-use state.

[0033]

The invention is not limited to the previously described details or to the features represented using Figures 1-3 but rather numerous changes and modifications are possible that a person skilled in the art with take as required without leaving the scope of the inventive concept.

List of reference numerals

1	Entire mold
2	Upper mold part
3	Opening
4	Entire hollow mold space
5	Slip supply apparatus
6	Slip line
7	Slip
8	Hollow body element
9	Tube section
10	Mold closure part

Claims

1. A process for slip casting under the action of pressure for producing ceramic goods, especially hollow ceramic goods, in which slip is filled into a hollow space of a mold formed by a mold and placed under pressure for forming bodies for the ceramic good, characterized in that after the filling of the hollow mold space with slip, an inflatable hollow body element of non-porous but flexible material is introduced into the slip by immersion into the slip and is then inflated by fluid pressure in the inner space of the hollow body element in the manner of a balloon for loading the slip with pressure when the mold is closed.

2. The process according to Claim 1, characterized in that the fluid pressure is produced by water.

3. The process according to Claim 1 or 2, characterized in that the hollow body element is introduced in the non-inflated state into the slip to the desired position and then the fluid pressure is built up in the inner space of the hollow body element, preferably in a gradually rising manner.

4. The process according to Claims 1-3, characterized in that after the body formation from the slip in the hollow mold space, the fluid pressure in the inner space of the hollow body element is also reduced, preferably gradually.

5. The process according to one of Claims 1-4, characterized in that the hollow body element is then removed after the body formation without fluid pressure from the hollow mold space.

6. The process according to one of Claims 1-5, characterized in that the inflatable hollow body element is connected in a movable manner to a mold closure part.

7. An apparatus for slip casting under the action of pressure for producing ceramic goods, especially hollow ceramic goods, with a mold (1) surrounding a hollow mold space (4) for slip casting under the action of pressure, characterized by a hollow body element (8), which can be inflated like a balloon by fluid pressure in the inner space, consisting of a non-porous, flexible material, and can be immersed in

the slip (7) in the hollow mold space (4) and removed from it in the emptied state after the body formation.

8. The apparatus according to Claim 7, characterized in that the inflatable hollow body element (8) is fastened on a free end of a rigid tube section (9) as holder that introduces the fluid pressure medium into the inner space of the hollow body element (8).

9. The apparatus according to Claim 8, characterized in that the inflatable hollow body element (8) is connected via the tube section (9) to a mold closure part (10) and can be moved together with the latter for immersion and removal.

10. The apparatus according to one of Claims 7-9, characterized by a separate slip line (6) for filling the still partially open hollow mold space (4) with slip (7) without immersing the inflatable hollow body element (8).

11. The apparatus according to Claim 10, characterized in that the slip line (6) allows a pressureless supplying of slip into the hollow mold space (4).

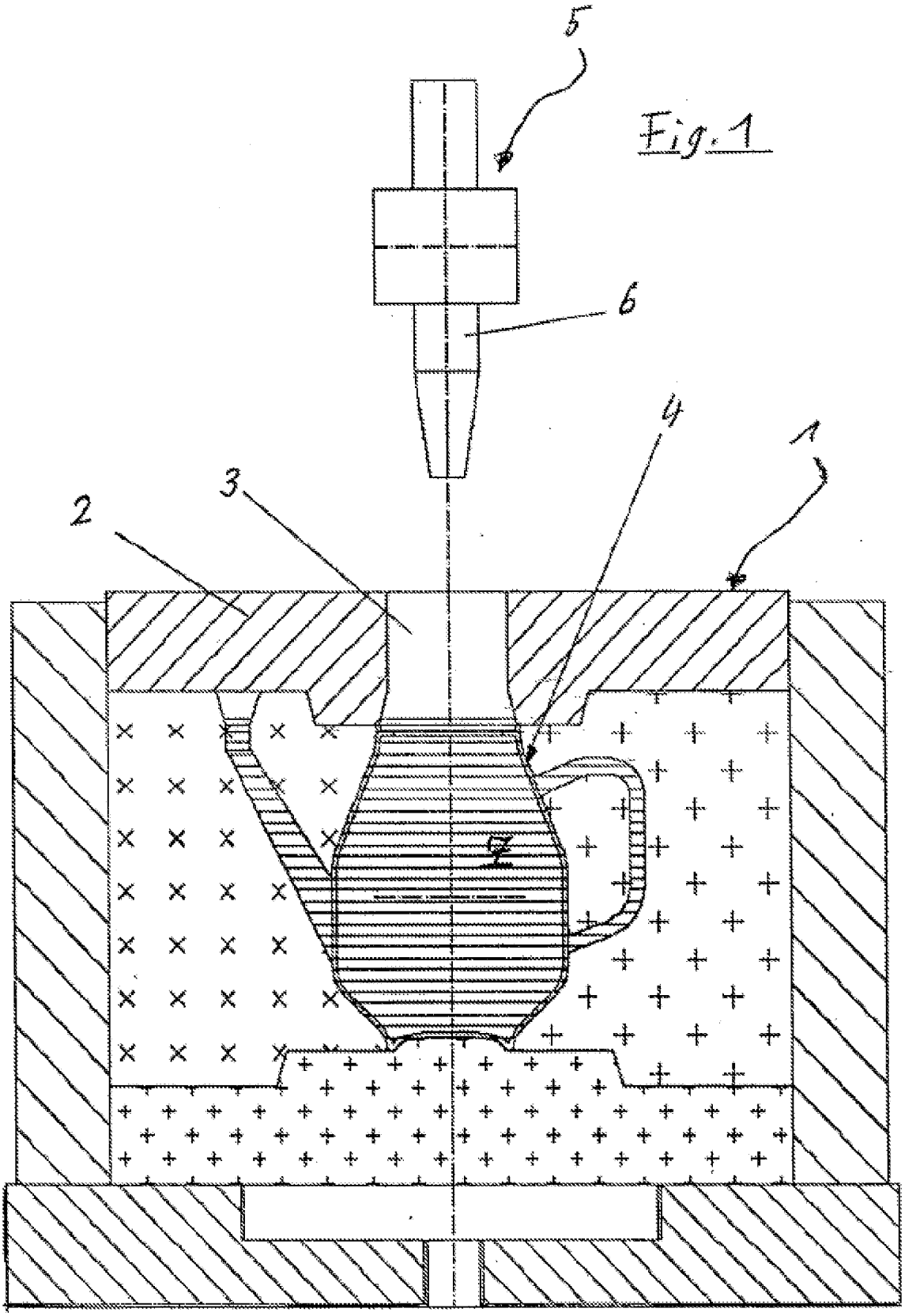

Fig. 1

Fig. 2

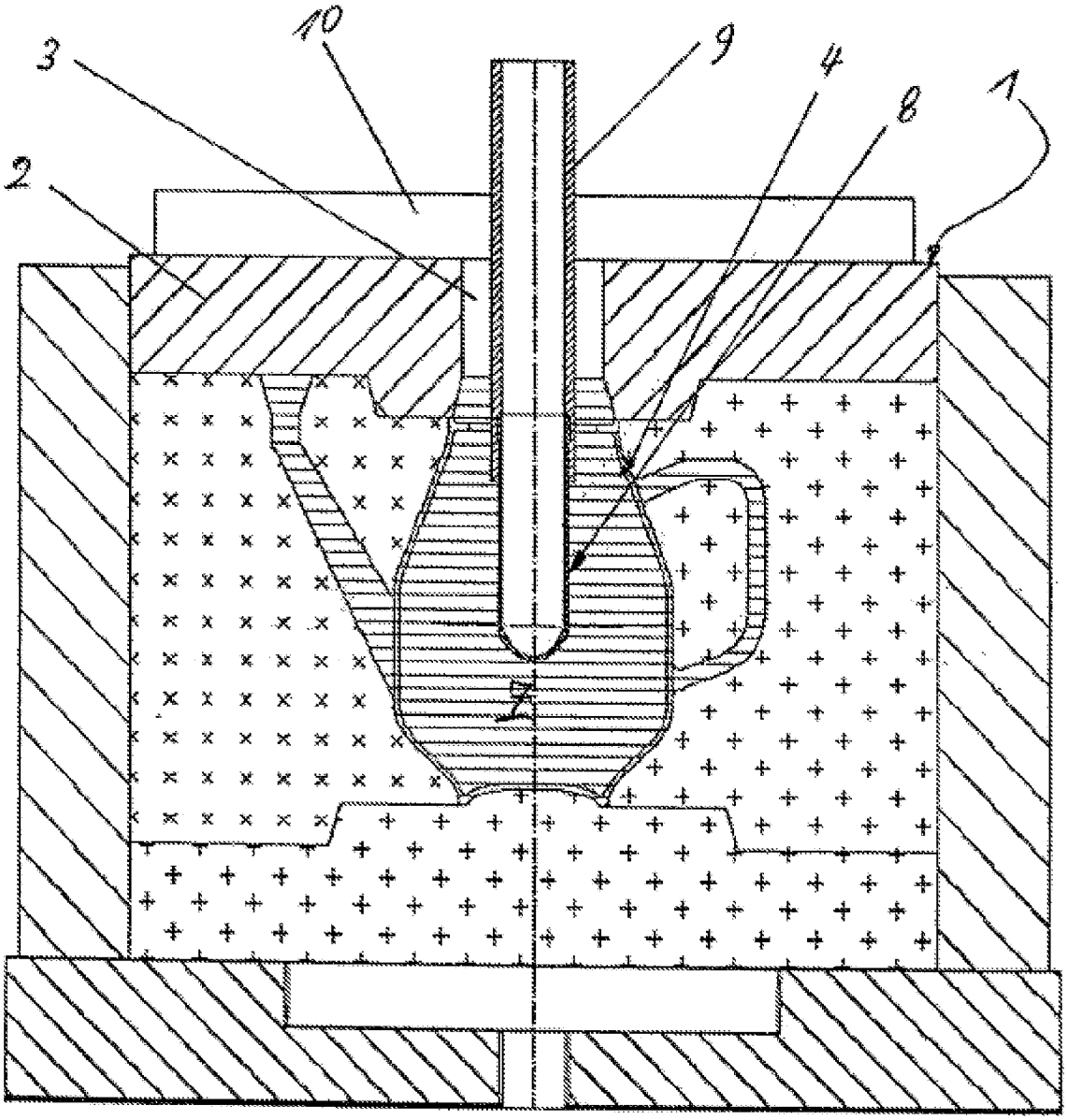

Fig. 3